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A Survey of the Poisonous Fishes of Johnston Island[1]

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(Text-figure 1)

INTRODUCTION

THIS paper is the second of a series of epidemiological reports concerning the poisonous fishes of various island areas in the tropical Pacific. The first report by the present authors (1953) dealt with the poisonous fishes of the Phoenix Islands. For a general résumé of the over-all problem of poisonous fishes and fish poisoning the reader is referred to two earlier papers (Halstead, 1951, 1953).

The problem of poisonous fishes represents one of the neglected fields of medical and ichthyological research. The existing confusion and lack of precise data regarding the identity, geographical distribution and biology of toxic fishes and the nature of ichthyosarcotoxins can only hamper the economic development of the shore fisheries of the tropical Pacific. The fact that a species of fish may be commercially valuable in one locality and violently toxic in another can be a major factor in outlawing otherwise valuable fishing grounds. Future world demands for protein food sources will necessitate a more rigid control and efficient utilization of the vast food reserves of the ocean, and consequently the problem of poisonous marine organisms will become of increasing importance. One of the primary objectives of the present series of investigations is to provide accurate epidemiological data on toxic fishes.

During February, 1951, Dr. Vernon E. Brock and his associates of the Division of Fish and Game for the Territory of Hawaii made a fishery survey of Johnston Island. The study revealed that poisonous fishes were a local public health menace. A small collection of reef fishes was captured, shipped to Loma Linda for analysis and subsequently found to be toxic. Plans for a more comprehensive study were formulated at the suggestion of Colonel Robert T. Cronau, USAF, who at that time was the Base Commander for Johnston Island. During May, 1951, the senior author made a preliminary survey in order to determine the collecting conditions, availability of small boat transportation and the probable incidence of ichthyosarcotoxism. In October and November, 1951, the junior author made a more complete field study and collected most of the specimens upon which the present report is based.

INCIDENCE AND CLINICAL CHARACTERISTICS OF FISH POISONING AT JOHNSTON

Johnston Island was uninhabited until 1909, when it was leased from the Territory of Hawaii by a private guano company (Bryan, 1942). The project did not succeed and the operation was soon closed. In 1926 the island was made a bird reservation. In 1934 it was placed under the jurisdiction of the United States Navy, but military personnel did not inhabit the island until about the latter part of 1939. Prior to 1939 there were no "permanent human residents," consequently there is only meager information regarding the edibility of the fish fauna before the arrival of the military. Mr. Edwin H. Bryan, Jr., of the Bernice P. Bishop Museum in Honolulu, who has maintained voluminous files on the Pacific islands for many years, believes that fish poisoning at Johnston Island is of recent origin. Mr. Bryan was a member of the scientific staff

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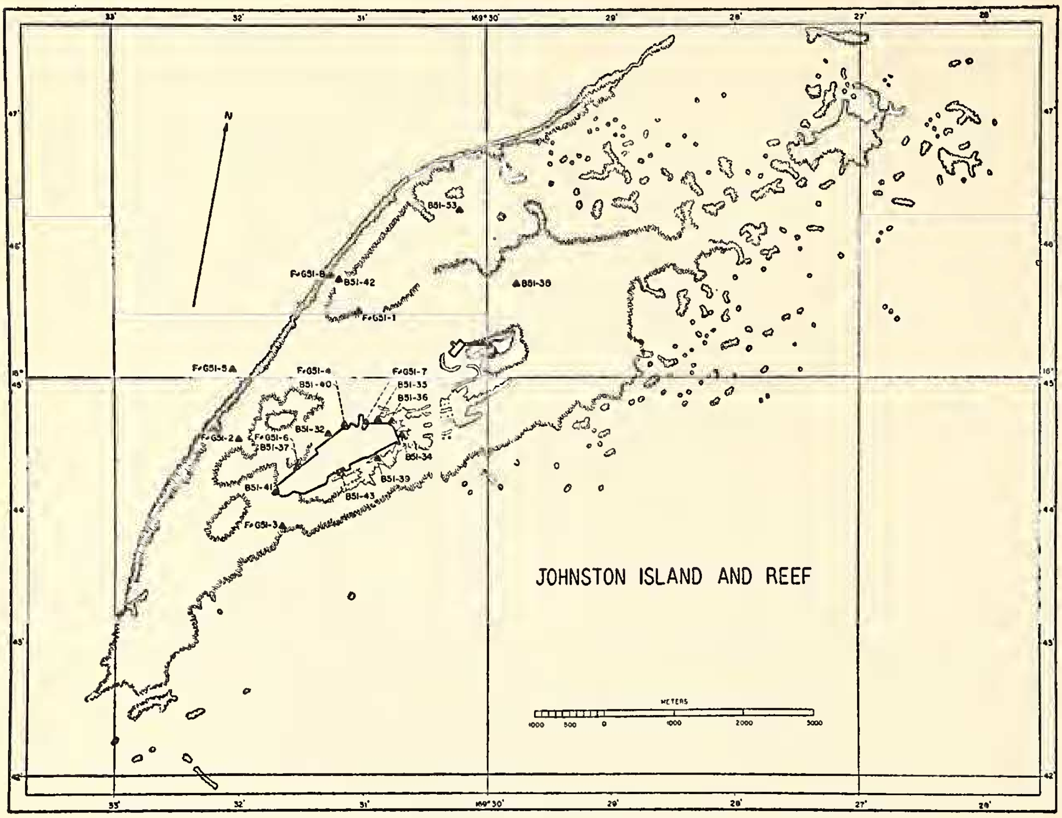

TEXT-FIG. 1. Map of Johnston Island showing field numbers of collecting stations.

of the Tanager Expedition which made a biological survey of the island in 1923. In a recent letter (1953) he stated "we caught and ate fish there, and I do not recall of anyone complaining of ill effects," and again, "I was there in 1944 and recall no mention of fish poisoning at that time."

The exact date as to when the fishes of Johnston Island became toxic is difficult to establish, but apparently it coincides with a general outbreak which appears to have started about 1943 at Palmyra, and then subsequently involved Kingman Reef, Christmas, Fanning, Midway and Johnston islands. Surprisingly, Washington and the principal Hawaiian islands apparently were not affected. Other areas may have been involved, but no record of such has come to our attention.

According to Captain John T. Martin, USAF, formerly the Base Surgeon at Johnston Island, the first documented case of fish poisoning occurred in August, 1950. Outbreaks were thought to have occurred prior to that time, but very little clinical information is available. Fishes captured inside of the lagoon were reportedly poisonous, while those taken outside of the lagoon were supposedly safe for human consumption. As a result of periodic outbreaks of fish poisoning among both civilian and military personnel it became generally known that such fishes as puffers (Tetraodontidae), triggerfish (Balistidae), saboti (*Kuhlia taeniura* (Cuvier)), ulua (*Caranx* spp.), "tuna" (probably *Euthynnus yaito* Kishinouye, a skipjack), "red or blue toothless snapper" (?), moray eels (Muraenidae), surmullet (Mullidae), etc., were dangerous to eat.

Despite the posted warnings and rigid regulations concerning the eating of reef fishes at Johnston, frequent intoxications have occurred. During the period from May, 1950, to May, 1951, it was estimated that there were approximately twenty outbreaks of ichthyosarcotoxism. In the past most of the intoxications have involved transient native civilian workers who were brought to Johnston from the Hawaiian islands. Since many of the same or similar fish species are commonly eaten in the Hawaiian area it is difficult to convince natives that the same fish elsewhere may be violently toxic.

The clinical picture of the cases that have occurred at Johnston generally resembles an acute

and often violent gastro-intestinal upset accompanied by various sensory disturbances. The onset of symptoms usually occurs within a period of two to three hours, consisting of nausea, vomiting, diarrhea and abdominal pain. The sensory disturbances, consisting of a tingling sensation in and about the mouth and extremities, may precede, accompany or develop subsequent to the gastro-intestinal symptoms. A mild to severe prostration, malaise, muscular cramps and pruritus may also be present. One patient complained of a "scalding sensation" upon defecation. Physical findings are not remarkable and treatment is generally symptomatic. There is no known antidote for the poison. Most of the patients have recovered within two or three days. Since a more complete analysis of the clinical characteristics of the disease is now in progress, no further mention will be made of the subject at this time.

Geography and Ecology of Johnston Island

Johnston Island (Text-fig. 1) is located at lat. 16° 45′ N. and long. 169° 30′ W., about 700 miles WSW of Honolulu (Hyd. Off., 1940; Robson, 1950; Bryan, 1942; Freeman, 1951). It consists of an isolated shallow bank that supports a luxuriant growth of coral-algal reefs and two small islets. The larger islet, Johnston Island, was formerly about 3,000 feet long and about 600 feet wide with a maximum elevation of about 40 feet. Sand Island, about one mile northwest of the main islet, is about one-quarter of a mile in diameter and is very low. The nearly open bank on which these islets are located is about eight miles long and is partly rimmed by an irregular, arrow-shaped, marginal coral-algal reef. The point of the arrow lies in the southwest direction. At the northeast end of the reef area are large clusters of patch reefs. Both Johnston and Sand Islands are protected from the open sea on the northwest by a ridge-like marginal reef which is five to twenty meters wide and which extends uninterrupted for about six miles in a southwest and northeast direction. A shelf-area of slightly deeper water extends out to sea for about 800 meters from the marginal reef and then drops precipitously to the 100-fathom line. The southeastern side of the bank is bordered by an expansive coral shoal area which extends for four or five miles out from the island and then slopes gradually down to the 100-fathom line and beyond. There is a dredged ship channel through the southern shoal area which makes the "lagoon" accessible to large vessels. Because of construction and dredging, the former island topography has been radically altered.

The mean tidal range is less than two feet, and the high-water interval at full and change is three hours and fifteen minutes. There is little rainfall and the island has no natural freshwater supply. During October and November, 1951, the average daily air temperature was about 30.5° C. Prevailing winds were from the east and northeast. The winds, which varied from a moderate to a strong breeze during most of the field study, made collecting very difficult.

Vegetation is very sparse, being confined to bunch grass and some small shrubs. A few coconut palms and larger shrubs have been introduced. Wild terrestrial life is limited largely to oceanic birds of the usual atoll variety. There is a general paucity of the larger forms of marine plant life. Most of the dead patch reefs, boulders, wood and metal pilings are covered with a fine growth of minute algal forms.

Reef Biochore and Collecting Stations[2]

The reef biochore of Johnston Island, for the purposes of this discussion, may be divided into the following biotopes:

Northern (Peripheral) Reef Area.—The exposed portion of the reef is comprised largely of dead corals. Living corals are located at sporadic intervals along the reef but are most plentiful along the slopes. Algal growth is minimal and consists largely of microscopic forms. The water in this general area is very clear. Water temperature on February 24, 1951, at 1400 was 25.5° C. Reef fishes are abundant in both number and species.

A. Open-water.—The seaward side of the reef is a typical open-water habitat without the protection of a coral reef. The bottom drops off precipitously. Inhabiting these offshore waters are scombroid fishes, barracuda, sharks and other pelagic species. Field No.: F&G51-5.

B. Coral.—The lagoon side of the peripheral reef and the vicinity immediately south of it are composed of corals in various stages of growth and decay. Some of the most luxuriant coral growths at Johnston are to be found in this vicinity. The water depth along the southern slope of the rim reef seldom exceeds 15 feet. Algal growth, exclusive of corallines, is minimal, and consists largely of microscopic forms. The water in this area is clear. Moray eels, butterfly, squirrel, surgeon, damsel, surmullet, puffer and file fishes are common. Eagle-rays may be occasionally observed in this biotope. Field Nos.: F&G 51-8; B51-43.

Southern (Shoal) Reef Area.—The southern reef curves around and joins the northern one at

[2] In the discussion concerned with reef ecology we have adopted the terminology as proposed by Cloud (1952).

the southwestern tip of the atoll. The reef extends northward for approximately six miles and then fades out as a series of patch reefs. This reef is comprised largely of dead coral which rests rather low in the water. Algal growth, exclusive of corallines, is minimal, consisting primarily of microscopic species. The water in this area is relatively murky compared to that of the northern reef. Water temperature on February 25, 1951, at 1400 was 25.8° C. Fish species are fewer in number and variety, compared to the northern reef.

A. Open-water.—An extensive shoal area extends south and southeast from the southern reef for about four or five miles and then gradually slopes into the deep open-water area. The water depth in most of the shoal area ranges from about seven to fourteen fathoms. Unfortunately facilities did not permit investigaton of this zone. Strong currents and a large shark population are said to exist in this area.

B. Coral.—The "lagoon" side of the southern reef consists largely of dead coral patches, knolls and rubble with scattered areas of sand. The water in this zone is generally shallow, a fathom or less in depth, and is relatively murky. A sparse fish population made this area undesirable for collecting purposes. Field No.: F&G51-3.

Bank Shoals.—The so-called "lagoon" is really the shoal water area above a partially rimmed bank that approaches but does not attain the form and structure of an atoll. It is about eight miles long and about two and a quarter miles wide at the widest point, is roughly triangular in outline, shallow and studded with numerous patch reefs of various sizes and shapes. The bank floor between patch reefs consists largely of calcium carbonate, sand and rubble of organic derivation. Reefs are most extensive in the immediate vicinity of the island. At the northwest end of the bank the reefs are broken up into a series of patchy areas which range in size from a few feet to a mile in diameter. Because of dredging, blasting and the resulting silt and debris in the water, most of the coral in the vicinity of the island has been killed. The fish population in the forementioned areas is generally sparse. However, many of the reef areas along the northern rim reef and at the northwest end of the bank support a thriving fish fauna. The water about the island, and especially on the southern side, is relatively murky, but is less turbid along the northern reef and at the northwest end of the atoll. The water temperature on February 23, 1951 at 1405 was 25.7° C., taken at station F&G51-1.

A. Patch Reefs.—The largest fish populations are generally found in the vicinity of living corals. Dead coral areas provide relatively poor collecting. Small coral knolls and other patch reefs provide an excellent habitat for many of the smaller reef fishes. Moray eels are especially plentiful in these regions. Other common inhabitants of the patch reef biotope consist of wrasse, parrot, cornet, surgeon, butterfly, squirrel, damsel and puffer fishes. Field Nos.: F&G 51-1; F&G 51-2; B51-33.

B. Sandy Areas Interspersed with Patch Reefs and Boulders.—The island shore is littered with large coral boulders which have been dredged for fill purposes. The only sandy beaches are located along the shore near stations B51-32, B51-37 and F&G51-6. The lagoon bottom in the vicinity of the island is largely of sand and patches of low, worn, dead corals. The bottom at station B51-38 is a dredged area consisting of sand and coral rubble. Station B51-38 is the garbage dumping area. The fish population is usually sparse except when refuse is being dumped, at which time sharks are plentiful. Fishes are generally most numerous in sandy areas adjoining living patch reefs. Representative fish species of this habitat are flounders, blennies, surmullet, pompano, puffers, pomacentrids, stingrays and triggerfishes. Field Nos.: F&G51-4; F&G51-6; F&G51-7; B51-32; B51-34; B51-35; B51-36; B51-37; B51-38; B51-39; B51-40; B51-43.

C. Wreckage.—The southwest end of the island is used as a dump and the shoreline is littered with scrap metal. The water attains a depth of about 12 feet in this area and is very murky. The bottom consists of coral boulders, sand, rubble and wreckage. Although this cannot be considered a natural biotope, the problem of fishes feeding around wreckage and thereby becoming toxic is one of the possibilities that must be taken into consideration. Hence, this zone is listed as a separate habitat. Species captured in this area are trumpet, parrot, damsel, pompano, trigger and butterfly fishes. Field No.: B51-41.

Taxonomic Studies

Effort was directed toward obtaining accurate taxonomic diagnoses of all material brought into the laboratory. A comprehensive systematic treatise of the fish fauna of Johnston Island is not to be found in the literature. Probably the earliest faunal study of this area is that by Smith & Swain (1882). A more recent account has been published by Fowler & Ball (1925). While the latter work includes a larger number of species, both reports are woefully inadequate. Systematic works found to be particularly useful have been published by the following authors: Schultz (1943), Weber & de Beaufort (1911-1951), Jordan & Evermann (1905), Fowler (1928, 1931, 1933, 1934, 1941), Fowler & Bean (1928, 1929, 1930), Günther (1873-1910),

Bleeker (1862-1877) and Smith (1950). In dealing with plectognaths, the nomenclature proposed by Fraser-Brunner (1935, 1941, 1943) has been largely adopted. Clark's (1949) review of the plectognath fishes was also found of value.

Dr. Leonard P. Schultz of the United States National Museum kindly supplied us with taxonomic keys from his Marshall Island report (Schultz, 1953). The authors are further indebted to Dr. Schultz for an identified collection of 743 specimens from the Marshall Islands, which proved to be of great value in making comparative studies. All of the scarids were identified by Dr. Schultz.

Representative specimens of all positive and negative material have been catalogued and preserved in the museum of the Department of Ichthyology and Herpetology of the School of Tropical and Preventive Medicine.

Methods Used in Screening Fishes

The reader is referred to the authors' (1953) report on the poisonous fishes of the Phoenix Islands for a résumé of the screening techniques of earlier workers. The technique described in the following paragraph has been adopted as the routine screening procedure for this laboratory. This method is a modification of one that was originally suggested by Karl F. Meyer and Hermann Sommer of the University of California.

Samples of the muscle, liver, intestine and gonads, whenever possible, are removed from each specimen to be tested. Care is taken to remove the sample from the right side of the fish so that the left side of the specimen remains intact for taxonomic purposes. If the fish is small it may be necessary to remove the entire viscera as a single sample. In rare instances it has been necessary to utilize the entire fish in order to obtain sufficient material for extraction. An attempt is made to remove about 7 gm of flesh for each sample. Two ml of distilled water are added for each gram of flesh. The material is then ground in a mortar or homogenized in a Waring Blendor. The homogenate is centrifuged at 2,000 rpm. for 25 minutes, using a head with an eight-inch radius. One ml of the supernatant fluid is injected intraperitoneally into each of four white laboratory mice (California Caviary Strain No. 1) weighing 15 to 25 gm. Their reactions are observed and recorded over a period of 36 hours.

Terminology Used Concerning Degrees of Toxicity.—The problem of determining the toxicity of reef fishes has necessitated developing a screening procedure which is roughly quantitative and at the same time suitable for processing large quantities of fishes within a reasonable period of time. No attempt is made to determine the LD_{50} as a routine measure because of the enormous expense involved. The classification presented in the following paragraph is an arbitrary one which does give some idea as to the degree of toxicity of a fish species within a particular geographical area. This method makes no attempt to differentiate between virulence and concentration of the toxin. The classification is based upon time in relationship to symptomatology.

Negative.—The test is negative if the mouse continues to remain asymptomatic during the maximum test period of 36 hours.

Weakly Positive.—The test is weakly positive if the mouse shows definite symptoms such as lacrimation, diarrhea, ruffling of the hair, hypoactivity, ataxia, etc., but the *animal recovers*[3].

Moderately Positive.—This term is used if the mouse develops hypoactivity, ruffling of the hair, lacrimation, diarrhea, paralysis, etc., *and dies within a period of one to 36 hours.* (It will be noted that this definition has been slightly modified from that in the Phoenix Island report (1953).

Strongly Positive.—The test is strongly positive if the mouse develops hypoactivity, ataxia and paralysis which is usually followed by clonic or tonic convulsions of varying degrees, paradoxical respiration, respiratory paralysis and *death occurs within a few seconds to one hour.*

Discussion

This study reveals that approximately 47% of the reef fishes tested from Johnson Island were toxic. The toxicity of any given species was extremely variable. The factors governing the toxicity of fishes are not understood at the present time. Apparently any species may become toxic if the proper environmental conditions are present. The spotty geographical distribution and the extreme fluctuation in toxicity within a single species indicate that the problem is basically concerned with the feeding habits of the fish. The reader is referred to the Phoenix Island report (Halstead & Bunker, 1953) for further discussion of the food chain theory.

Since many of the data in this report are of a preliminary nature, premature conclusions

[3] The "intraperitoneal injection syndrome" should be distinguished from the toxic symptoms resulting from the injection of ichthyosarcotoxins. The injection syndrome may be observed when 1 ml of distilled water is used. Immediately following the injection, respiration rate and usually depth are increased, and the animal remains normally crouched for a few minutes. This is followed by alternate stretching of the hind legs and restlessness. In some mice there is an opisthotonoid arching of the back lasting less than one minute, and which may be concomitant with any other responses.

TABLE 1. AN ANALYSIS OF JOHNSTON ISLAND FISHES WITH REFERENCE TO THEIR TOXICITY

Extract No.	Family and Species with their English and Hawaiian names	Locality No.	Part of Fish*	Results†
	ACANTHURIDAE—Surgeonfish, Tang, Maiii, Pararo			
242-1	*Acanthurus achilles* Shaw	F&G51-2	M	N
905-1,5	" "	B51-42	M	N
			V	M
502-1,3,4	" "	"	M,G,I	N
503-1,3,4	" "	"	M,G,I	N
863-1,5	*Acanthurus elongatus* (Lacépède)	B51-32	M,V	W
482-1,2	" "	"	M,L	N
483-1,5	" "	"	M,V	N
861-1,5	" "	B51-34	M,V	W
864-1,5	" "	"	M	N
			V	M
865-1,5	" "	"	M	N
			V	W
862-1,5	" "	"	M	W
			V	M
461-1,5	" "	"	M,V	N
462-1,5	" "	"	M,V	N
860-1,5	" "	B51-42	M,V	W
946-1,5	" "	"	M	W
			V	M
954-1,5	" "	"	M,V	W
216-1	" "	F&G51-3	M	N
481-1,2,4	*Acanthurus olivaceus* Bloch	B51-32	M,L	N
			I	M
520-1,5	" "	B51-34	M,V	N
899-1,5	" "	"	M	M
			V	W
539-1,2,4	" "	"	M,L,I	N
454-1	" "	B51-34	M	N
455-1	" "	"	M	N
932-1,5	*Acanthurus triostegus* (Linnaeus)	"	M	W
			V	M
922-1,5	" "	"	M	W
			V	M
463-1,5	" "	"	M,V	N
218-1	" "	F&G51-3	M	N
239-1	" "	F&G51-6	M	N
884-1,5	*Ctenochaetus striatus* (Quoy & Gaimard)	B51-34	M	N
			V	W
508-1,5	" "	B51-42	M	N
			V	W
882-1,5	" "	"	M	W
			V	N
517-1,5	" "	"	M,V	N
507-1,5	" "	"	M	N
			V	M
883-1,5	" "	"	M	W
			V	M
362-1,5	" "	F&G51-8	M,V	N

* Letters in this column refer to: M—Muscle; V—Viscera; G—Gonads; I—Intestine; L—Liver; WF—Whole Fish.
† Letters in this column refer to: N—Negative; W—Weakly Positive; M—Moderately Positive; S—Strongly Positive.

TABLE 1. *Continued*

Extract No.	Family and Species with their English and Hawaiian names	Locality No.	Part of Fish*	Results†
479-1	*Naso lituratus* (Bloch)	B51-32	M	N
480-1	" "	"	M	N
855-1,5	" "	"	M,V	W
856-1,5	" "	B51-34	M,V	W
857-1,5	" "	"	M,V	W
498-1,2,4	" "	B51-42	M,L,I	N
213-1	" "	F&G51-3	M	N
952-8	*Zebrasoma flavescens* (Bennett)	B51-42	WF	W
	ALUTERIDAE—Filefish or Leather Jacket, Oili or Ohua			
473-1,2	*Amanses carolae* (Jordan & McGregor)	B51-42	M,L	N
472-1,2	" "	"	M,L	N
943-8	*Amanses sandwichiensis* (Quoy & Gaimard)	"	WF	W
	AULOSTOMIDAE—Trumpetfish, Nunu			
937-1	*Aulostomus chinensis* (Linnaeus)	B51-32	M	W
925-1,2,3,4	" "	B51-34	M,I	N
			L	M
			G	W
924-1	" "	"	M	N
535-1,2,3,4	" "	"	M	W
			L	M
			G,I	N
550-1,5	" "	B51-41	M,V	N
	BALISTIDAE—Triggerfish, Humuhumu			
880-1,2,4	*Melichthys ringens* (Osbeck)	B51-33	M,L	W
			I	M
540-1,2,4	" "	B51-41	M,L,I	N
541-1,2,4	" "	"	M,L,I	N
542-1,2,4	" "	"	M,L	N
			I	M
477-1,5	" "	B51-42	M,V	N
499-1,2	" "	"	M,L	N
501-1,2	" "	"	M,L	N
881-1,5	" "	"	M	W
			V	M
243-1	" "	F&G51-2	M	N
211-1	" "	F&G51-3	M	W
361-1,2,4	" "	F&G51-8	M,L,I	N
521-1,2,3,4	*Melichthys vidua* (Solander)	B51-34	M,G,I	N
			L	M
492-1,5	" "	B51-42	M	N
			V	M
459-1,2,3	*Rhinecanthus aculeatus* (Linnaeus)	B51-34	M,L,G	N
845-1,2,4	" "	B51-38	M,L,I	M
543-1,2,4	" "	B51-41	M,L,I	N
	BELONIDAE—Needlefish or Saltwater Gars, Aha aha			
923-1,5	*Belone platyura* Bennett	B51-42	M	N
			V	W

* Letters in this column refer to: M—Muscle; V—Viscera; G—Gonads; I—Intestine; L—Liver; WF—Whole Fish.

† Letters in this column refer to: N—Negative; W—Weakly Positive; M—Moderately Positive; S—Strongly Positive.

TABLE 1. *Continued*

Extract No.	Family and Species with their English and Hawaiian names	Locality No.	Part of Fish*	Results†
	BOTHIDAE—Flatfish or Flounders, Pakii			
490-1,5	*Bothus mancus* (Broussonet)	B51-34	M,V	N
470-1,2,4	" "	B51-37	M,L,I	N
	CANTHIGASTERIDAE—Sharp-nosed puffers			
938-8	*Canthigaster jactator* (Jenkins)	B51-32	WF	W
	CARANGIDAE—Pompano, Ulua (large specimens) or Papio (small specimens)			
850-1,5	*Carangoides ferdau jordani* Nichols	B51-42	M,V	M
237-1	" " "	F&G51-1	M	N
230-1	" " "	"	M	N
232-1	" " "	"	M	N
233-1	" " "	"	M	N
231-1	*Caranx lugubris* Poey	F&G51-1	M	N
548-1	" "	B51-41	M	N
965-1,5	" "	B51-38	M,V	W
966-1,5	" "	"	M,V	W
468-1	" "	B51-34	M	N
468-1	*Caranx melampygus* Cuvier	B51-34	M	N
548-1	" "	B51-41	M	N
965-1,5	" "	B51-38	M,V	W
966-1,5	" "	B51-38	M,V	W
	CHAETODONTIDAE—Butterflyfish, Kikakapu or Lauhau			
547-1,5	*Chaetodon auriga* Forskål	B51-41	M	N
			V	M
500-1,2	" "	B51-42	M,L	N
505-1,5	" "	"	M	N
			V	M
478-1,5	" "	"	M,V	N
514-1,5	" "	"	M,V	N
506-1,5	" "	"	M,V	M
209-1	" "	F&G51-3	M	N
944-8	*Chaetodon citrinellus* Cuvier	B51-34	WF	M
927-1,5	*Chaetodon ephippium* Cuvier	"	M,V	W
934-1,5	" "	"	M,V	W
456-1,5	*Chaetodon ornatissimus* Cuvier & Valenciennes	"	M,V	N
524-1,5	" "	"	M,V	N
525-1,5	" "	"	M,V	N
926-1,5	" "	"	M	W
			V	M
532-1,3,4	" "	"	M,G,I	N
928-1,5	*Chaetodon punctato-fasciatus* Cuvier	B51-42	M,V	M
931-1,5	" " "	"	M,V	W
512-1,5	*Megaprotodon strigangulus* (Gmelin)	"	M,V	N
	HOLOCENTRIDAE—Squirrelfish, U'u			
956-5	*Holocentrus lacteoguttatus* Cuvier	B51-42	V	W
962-1	" "	"	M	W

* Letters in this column refer to: M—Muscle; V—Viscera; G—Gonads; I—Intestine; L—Liver; WF—Whole Fish.

† Letters in this column refer to: N—Negative; W—Weakly Positive; M—Moderately Positive; S—Strongly Positive.

TABLE 1. *Continued*

Extract No.	Family and Species with their English and Hawaiian names	Locality No.	Part of Fish*	Results†
529-1,5	*Holocentrus sammara* (Forskål)	B51-34	M,V	N
854-1,5	*Holocentrus spinifer* (Forskål)	B51-32	M,V	W
523-1,2,4	" "	B51-34	M,L,I	N
530-1,2,4	" "	"	M,L,I	N
875-1,5	" "	B51-35	M,V	N
853-1,3,4	" "	B51-42	M,G	N
			I	W
219-1	" "	F&G51-3	M	N
236-1	" "	F&G51-4	M	N
942-8	*Holocentrus tiere* Cuvier & Valenciennes	B51-42	WF	N
504-1,5	" "	"	M,V	N
515-1,5	" "	"	M,V	N
314-1,5	*Myripristis argyromus* Jordan & Evermann	F&G51-8	M,V	N
953-8	" "	B51-42	WF	W
901-1,5	" "	"	M,V	W
900-1,5	*Myripristis berndti* Jordan & Evermann	"	M,V	W
	KYPHOSIDAE—Rudderfish, Nanue			
491-1,5	*Kyphosus bigibbus* Lacépède	B51-42	M,V	N
	LABRIDAE—Wrasse, Hinalea			
465-1,2,4	*Cheilinus rhodochrous* Günther	B51-33	M,L,I	N
466-1,2,4	" "	"	M,L,I	N
467-1,5	" "	"	M,V	N
963-1,5	" "	B51-42	M	N
			V	W
234-1	" "	F&G51-5	M	N
531-1,2	*Epibulus insidiator* (Pallas)	B51-34	M,L	N
846-1,5	" "	B51-42	M,V	W
847-1,2,4	" "	"	M	N
			L,I	M
215-1	" "	F&G51-3	M	N
476-1	*Thalassoma duperrey* (Quoy & Gaimard)	B51-42	M	N
	MULLIDAE—Surmullet, Goatfish, Weke or Moano			
939-1	*Mulloidichthys auriflamma* (Forskål)	B51-42	M	W
311-1	" "	F&G51-7	M	N
458-1,5	*Mulloidichthys samoensis* (Günther)	B51-34	M,V	N
935-1,5	" "	"	M	W
			V	M
496-1,5	" "	B51-42	M,V	N
902-1,5	" "	"	M,V	W
238-1	" "	F&G51-2	M	N
210-1	" "	F&G51-3	M	N
360-1,5	" "	F&G51-8	M,V	N
903-1,5	*Parupeneus bifasciatus* (Lacépède)	B51-34	M,V	W
528-1	" "	"	M	N
513-1	" "	B51-42	M	N

* Letters in this column refer to: M—Muscle; V—Viscera; G—Gonads; I—Intestine; L—Liver; WF—Whole Fish.
† Letters in this column refer to: N—Negative; W—Weakly Positive; M—Moderately Positive; S—Strongly Positive.

TABLE 1. *Continued*

Extract No.	Family and Species with their English and Hawaiian names	Locality No.	Part of Fish*	Results†
851-1,2,4	*Parupeneus chryserydros* (Lacépède)	B51-32	M	N
			L	M
			I	W
852-1,5	" "	B51-42	M,V	W
214-1	*Parupeneus crassilabris* (Valenciennes)	F&G51-3	M	N
898-1,5	*Parupeneus trifasciatus* (Lacépède)	B51-34	M	N
			V	W
509-1,5	" "	B51-42	M	W
			V	M
904-1,5	" "	"	M	W
			V	W
212-1	" "	F&G51-3	M	N
	MURAENIDAE—Moray eel, Puhi			
464-1,5	*Gymnothorax buroensis* (Bleeker)	B51-34	M,V	N
534-1,5	" "	"	M,V	N
947-5	" "	B51-42	V	W
475-1,5	" "	"	M,V	N
217-1	" "	F&G51-3	M	N
951-1,2,4	*Gymnothorax javanicus* (Bleeker)	B51-34	M,I	W
			L	M
471-1,2,4	" "	B51-37	M,L,I	N
518-1,5	*Gymnothorax meleagris* (Shaw & Nodder)	B51-42	M,V	N
474-1,2,4	" "	"	M,I	N
			L	M
	MYLIOBATIDAE—Eagleray, Hihimanu			
948-1,2,4	*Aëtobatus narinari* (Euphrasen)	B51-42	M	N
			L,I	W
	OSTRACIONTIDAE—Trunkfish, Moa			
936-8	*Kentrocapros hexagonus* (Thunberg)	B51-34	WF	N
873-1,5	*Ctenochaetus striatus* (Quoy & Gaimard)	"	M	N
			V	W
871-1,5	" "	"	M,V	M
866-1,5	" "	"	M,V	M
867-1,5	" "	"	M	W
			V	M
868-1,5	" "	"	M	W
			V	M
869-1,5	" "	"	M	N
			V	M
870-1,5	" "	"	M,V	M
872-1,5	" "	"	M	W
			V	M
874-1,5	" "	B51-37	M,V	W
879-1,5	*Ostracion cubicus* Linnaeus	B51-42	M,V	M
	POMACENTRIDAE—Damselfish, Mamamo			
930-1,5	*Abudefduf johnstonianus* (Fowler & Ball)	B51-42	M,V	W

* Letters in this column refer to: M—Muscle; V—Viscera; G—Gonads; I—Intestine; L—Liver; WF—Whole Fish.
† Letters in this column refer to: N—Negative; W—Weakly Positive; M—Moderately Positive; S—Strongly Positive.

TABLE 1. *Continued*

Extract No.	Family and Species with their English and Hawaiian names	Locality No.	Part of Fish*	Results†
949-1,5	*Abudefduf sordidus* (Forskål)	B51-41	M,V	W
544-1,5	" "	"	M	N
			V	W
546-1,5	" "	"	M,V	N
876-1,5	" "	"	M	M
			V	W
878-1,5	" "	"	M,V	W
545-1,5	" "	"	M	N
			V	W
877-1,5	" "	"	M,V	W
363-1,5	*Dascyllus marginatus* (Rüppell)	F&G51-8	M,V	N
941-8	" "	B51-42	WF	W
945-8	" "	"	WF	W
929-1,5	" "	"	M	W
			V	M
	PRIACANTHIDAE—Big Eye, Alalauwa or Aweoweo			
940-8	*Priacanthus cruentatus* (Lacépède)	B51-42	WF	W
240-1	" "	F&G51-4	M	N
	SCARIDAE—Parrotfishes, Panuhunuhu			
549-1,5	*Scarus brunneus* Jenkins	B51-41	M,V	N
484-1	*Scarus cyanogrammus* (Jordan & Seale)	B51-34	M	N
519-1	*Scarus duperrey* (Quoy & Gaimard)	B51-42	M	N
538-1	*Scarus forsteri* Valenciennes	B51-34	M	N
469-1,2	*Scarus perspicillatus* Steindachner	B51-37	M,L	N
485-1	" "	B51-34	M	N
486-1,2	" "	"	M,L	N
487-1,2	" "	"	M,L	N
488-1,2	" "	"	M,L	N
967-1,2,3,4	" "	"	M,L,G,I	W
526-1,2,4	" "	"	M,L,I	N
527-1,2,4	" "	"	M,L,I	N
533-1,2	" "	"	M	N
			L	W
536-1,2	" "	"	M,L	N
537-1,2	" "	"	M,L	N
493-1,2	" "	B51-42	M,L	N
522-1,2	*Scarus sordidus* Forskål	B51-34	M,L	N
511-1,5	" "	B51-42	M,V	N
516-1,5	" "	"	M,V	N
235-1	" "	F&G51-2	M	N
268-1,5	" "	F&G51-3	M,V	N
372-1,5	" "	"	M,V	N
377-1,5	" "	"	M,V	N
	TETRAODONTIDAE—Puffer, Globefish, Oopuhue or Maki-maki			
844-1,2,3,4	*Arothron meleagris* (Lacépède)	B51-32	M,L	W
			G,I	S
359-1,2,4	" "	F&G51-8	M	N
			L	S
			I	M
	ZANCLIDAE—Moorish Idols, Kihikihi Loula			
933-8	*Zanclus cornutus* (Linnaeus)	B51-34	WF	W

* Letters in this column refer to: M—Muscle; V—Viscera; G—Gonads; I—Intestine; L—Liver; WF—Whole Fish.
† Letters in this column refer to: N—Negative; W—Weakly Positive; M—Moderately Positive; S—Strongly Positive.

TABLE 2. SHOWING THE RELATIVE DISTRIBUTION OF POISON AMONG THE VARIOUS ORGANS OF THE FISH

Species	Total No. of Specimens Tested	Muscle		Viscera		Liver		Gonads		Intestine		Whole Fish	
		No.	% Pos.	No.	% Pos.	No.	% Pos.	No.	% Pos.	No.	% Pos.	No.	% Pos.
ACANTHURIDAE													
Acanthurus achilles Shaw	4	4	0	1	0	—	—	2	0	2	0	—	—
Acanthurus elongatus (Lacépède)	13	13	46	11	73	1	0	—	—	—	—	—	—
Acanthurus olivaceus Bloch	6	6	17	2	50	2	0	—	—	2	50	—	—
Acanthurus triostegus (Linnaeus)	5	5	40	3	67	—	—	—	—	—	—	—	—
Ctenochaetus striatus (Quoy & Gaimard)	7	7	29	7	57	—	—	—	—	—	—	—	—
Naso lituratus (Bloch)	7	7	43	3	100	1	0	—	—	1	0	—	—
Zebrasoma flavescens (Bennett)	1	—	—	—	—	—	—	—	—	—	—	1	100
ALUTERIDAE													
Amanses carolae (Jordan & McGregor)	2	2	0	—	—	2	0	—	—	—	—	—	—
Amanses sandwichiensis (Quoy & Gaimard)	—	—	—	—	—	—	—	—	—	—	—	1	100
AULOSTOMIDAE													
Aulostomus chinensis (Linnaeus)	5	5	40	1	0	2	100	2	50	2	0	—	—
BALISTIDAE													
Melichthys ringens (Osbeck)	11	11	27	2	50	7	14	—	—	5	40	—	—
Melichthys vidua (Solander)	2	2	0	1	100	1	100	1	0	1	0	—	—
Rhinecanthus aculeatus (Linnaeus)	3	3	33	—	—	3	33	1	0	2	50	—	—
BELONIDAE													
Belone platyura Bennett	1	1	0	1	100	—	—	—	—	—	—	—	—
BOTHIDAE													
Bothus mancus (Broussonet)	2	2	0	1	0	1	0	—	—	1	0	—	—
CANTHIGASTERIDAE													
Canthigaster jactator (Jenkins)	1	—	—	—	—	—	—	—	—	—	—	1	100
CARANGIDAE													
Carangoides ferdau jordani Nichols	5	5	20	1	100	—	—	—	—	—	—	—	—
Caranx lugubris Poey	1	1	0	—	—	—	—	—	—	—	—	—	—
Caranx melampygus Cuvier	4	4	50	2	100	—	—	—	—	—	—	—	—

TABLE 2.—*Continued*

Species	Total No. of Specimens Tested	Muscle		Viscera		Liver		Gonads		Intestine		Whole Fish	
		No.	% Pos.	No.	% Pos.	No.	% Pos.	No.	% Pos.	No.	% Pos.	No.	% Pos.
CHAETODONTIDAE													
Chaetodon auriga Forskål	7	7	14	5	60	1	0	—	—	—	—	—	—
Chaetodon citrinellus Cuvier	1	—	—	—	—	—	—	—	—	—	—	1	100
Chaetodon ephippium Cuvier	2	2	100	2	100	—	—	—	—	—	—	—	—
Chaetodon ornatissimus Cuvier & Valenciennes	5	5	20	4	25	—	—	1	0	1	0	—	—
Chaetodon punctato-fasciatus Cuvier	2	2	100	2	100	—	—	—	—	—	—	—	—
Megaprotodon strigangulus	1	1	0	1	0	—	—	—	—	—	—	—	—
HOLOCENTRIDAE													
Holocentrus lacteoguttatus Cuvier	2	1	100	1	100	—	—	—	—	—	—	—	—
Holocentrus sammara (Forskål)	1	1	0	1	0	—	—	—	—	—	—	—	—
Holocentrus spinifer (Forskål)	7	7	14	2	50	2	0	1	0	1	100	—	—
Holocentrus tiere Cuvier & Valenciennes	3	2	0	2	0	—	—	—	—	—	—	1	0
Myripristis argyromus Jordan & Evermann	3	2	50	2	50	—	—	—	—	—	—	1	100
Myripristis berndti Jordan & Evermann	1	1	100	1	100	—	—	—	—	—	—	—	—
KYPHOSIDAE													
Kyphosus bigibbus Lacépède	1	1	0	1	0	—	—	—	—	—	—	—	—
LABRIDAE													
Cheilinus rhodochrous Günther	5	5	0	2	50	2	0	—	—	2	0	—	—
Epibulus insidiator (Pallas)	4	4	25	1	100	2	50	—	—	1	100	—	—
Thalassoma duperrey (Quoy & Gaimard)	1	1	0	—	—	—	—	—	—	—	—	—	—
MULLIDAE													
Mulloidichthys auriflamma (Forskål)	2	2	50	—	—	—	—	—	—	—	—	—	—
Mulloidichthys samoensis (Günther)	7	7	29	5	40	—	—	—	—	—	—	—	—
Parupeneus bifasciatus (Lacépède)	3	3	33	1	100	—	—	—	—	—	—	—	—
Parupeneus crassilabris (Valenciennes)	1	1	0	—	—	—	—	—	—	—	—	—	—
Parupeneus chryserydros (Lacépède)	2	2	50	1	100	1	100	—	—	1	100	—	—
Parupeneus trifasciatus (Lacépède)	4	4	50	3	100	—	—	—	—	—	—	—	—
MURAENIDAE													
Gymnothorax buroensis (Bleeker)	5	4	0	4	25	—	—	—	—	—	—	—	—
Gymnothorax javanicus (Bleeker)	2	2	50	—	—	2	50	—	—	2	50	—	—
Gymnothorax meleagris (Shaw & Nodder)	2	2	0	1	0	1	100	—	—	1	0	—	—

Table 2.—*Continued*

Species	Total No. of Specimens Tested	Muscle		Viscera		Liver		Gonads		Intestine		Whole Fish	
		No.	% Pos.	No.	% Pos.	No.	% Pos.	No.	% Pos.	No.	% Pos.	No.	% Pos.
Myliobatidae													
Aëtobatus narinari (Euphrasen)	1	1	0	–	–	1	100	–	–	1	100	–	–
Ostraciontidae													
Kentrocapros hexagonus (Thunberg)	1	–	–	–	–	–	–	–	–	–	–	1	0
Ostracion meleagris Shaw	9	9	77	9	100	–	–	–	–	–	–	–	–
Ostracion cubicus Linnaeus	1	1	100	1	100	–	–	–	–	–	–	–	–
Pomacentridae													
Abudefduf johnstonianus (Fowler & Ball)	1	1	100	1	100	–	–	–	–	–	–	–	–
Abudefduf sordidus (Forskål)	7	7	57	7	86	–	–	–	–	–	–	–	–
Dascyllus marginatus (Rüppell)	4	2	50	2	50	–	–	–	–	–	–	2	100
Priacanthidae													
Priacanthus cruentatus (Lacépède)	2	1	0	–	–	–	–	–	–	–	–	1	100
Scaridae													
Scarus brunneus Jenkins	1	1	0	1	0	–	–	–	–	–	–	–	–
Scarus cyanogrammus (Jordan & Seale)	1	1	0	–	–	–	–	–	–	–	–	–	–
Scarus duperrey (Quoy & Gaimard)	1	1	0	–	–	–	–	–	–	–	–	–	–
Scarus forsteri Valenciennes	1	1	0	–	–	–	–	–	–	–	–	–	–
Scarus perspicillatus Steindachner	12	12	8	–	–	11	18	1	100	3	33	–	–
Scarus sordidus Forskål	7	7	0	5	0	1	0	–	–	–	–	–	–
Tetraodontidae													
Arothron meleagris (Lacépède)	2	2	50	–	–	2	100	1	100	2	100	–	–
Zanclidae													
Zanclus cornutus (Linneaus)	1	–	–	–	–	–	–	–	–	–	–	1	100
Summary	206	194	30	104	62	46	30	10	30	31	39	11	82

TABLE 3. ANALYSIS OF THE FAMILIES TESTED AND PERCENTAGE FOUND TOXIC

Families	Number of Species Tested	Percentage Positive
Acanthuridae	7	100
Aluteridae	2	50
Aulostomidae	1	100
Balistidae	3	100
Belonidae	1	100
Bothidae	1	0
Canthigasteridae	1	100
Carangidae	3	67
Chaetodontidae	6	83
Holocentridae	6	67
Kyphosidae	1	0
Labridae	3	67
Mullidae	6	83
Muraenidae	3	100
Myliobatidae	1	100
Ostraciontidae	3	67
Pomacentridae	3	100
Priacanthidae	1	100
Scaridae	6	17
Tetraodontidae	1	100
Zanclidae	1	100
Total	60	75%

regarding the edibility of Johnson Island reef fishes should be avoided. A larger series of specimens for each species must be collected and analyzed before any statistically valid conclusions can be reached. Moreover, there is some question as to the interpretation of "Weakly Positive" extracts in terms of human symptomatology.

In general it can be concluded that the viscera of a reef fish is more likely to be toxic than the somatic musculature. In the present series of fishes there were 153 specimens in which both the musculature and viscera (whole or in part) were tested; of these, 82 specimens were found to be poisonous. Fifty-three or 64% of the poisonous fishes tested had toxic musculature, whereas 80 specimens or 98% had toxic viscera.

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SUMMARY

Fishes were collected at Johnston Island during the months of February, October and November, 1951. Fish poisoning at Johnston Island is believed to be of recent origin and a part of the general outbreak which started about 1943 at Palmyra Island, later involving other Line and Midway islands. The exact geographical distribution and causative factors concerning fish poisoning are not known. From May, 1950, to May, 1951, there were approximately 20 cases of ichthyosarcotoxism at Johnston.

Fishes were screened by preparing, whenever possible, aqueous extracts of the muscle, liver, intestine and gonads of each specimen. Four laboratory white mice were used for testing each extract. One ml of the extract was used for each mouse. The mice were observed for a period of 36 hours and then classified as negative, weakly, moderately or strongly positive on the basis of symptoms developed. Twenty-one families representing 60 species and a total of 206 specimens were tested. Of these,

TABLE 4. SUMMARY OF TABLES 1, 2 AND 3

	Species	Specimens	Muscle	Viscera	Liver	Gonads	Intestines	Whole Fish
Total Tested	60	206	194	104	46	10	31	11
Total Found Toxic	45	96	57	64	14	3	12	9
Percent Found Toxic	75	47	30	62	30	30	39	82

TABLE 5. DISTRIBUTION OF TOXIN IN MUSCLE AND VISCERA (As found in 82 specimens of a total of 153 specimens tested for both muscle and viscera toxicity)

	Viscera	Muscle	Viscera and Muscle
Number of Toxic Specimens	80	53	52
Percent Toxic of Total Tested Specimens (153)	52	35	34
Percent Toxic of Total Toxic Specimens (82)	98	64	63

45 species and 96 specimens, or about 75% of the species and 47% of the specimens, were found to be toxic. There were 153 specimens in which both the musculature and viscera (whole or in part) were tested. Fifty-three or 64% of the toxic fishes tested had toxic musculature whereas 80 specimens or about 98% of the toxic fishes had toxic viscera. Both musculature and viscera were toxic in 63 specimens or 39%. A more complete analysis of the toxicity distribution appears in Tables 4 and 5.

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